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TRENDS OF CPUE FOR ATLANTIC BLUEFIN CAUGHT BY THE JAPANESE LONGLINE FISHERY UP TO 1992

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SUMMARY

The abundance indices from the Japanese longline fishery, which operates in the western Atlantic were developed for three age groups (3-5, 6-7, and 8 years old and older) as in the previous paper (Miyabe 1991). CPUE in the Gulf of Mexico was also re-analyzed. The estimated indices in the northwest show similar results of past studies but an increasing trend in the most recent year(s). A refined index of the Gulf of Mexico indicates a consistent decreasing trend during 1974-1981.

RESUME

Les indices d'abondance de la pêcherie palangrière japonaise qui pêche dans l'Atlantique ouest ont été élaborés pour trois groupes d'âges (3-5, 6-7 et 8+) comme dans le document précédent (Miyabe, 1991). La CPUE du golfe du Mexique a aussi été analysée de nouveau. Les indices estimés du nord-ouest donnent des résultats semblables à ceux des études antérieures, mais une tendance à la hausse pour les années les plus récentes. L'indice affiné du golfe du Mexique montre une tendance constamment décroissante de 1974 à 1981.

RESUMEN

Se desarrollaron índices de abundancia de la pesquería japonesa de palangre que opera en el Atlántico oeste, para tres grupos de edad (3-5, 6-7 y 8 y más), igual que en un documento anterior (Miyabe 1991). También se analizó de nuevo la CPUE en el Golfo de México. Los índices estimados en el noroeste muestran resultados similares a los de estudios realizados en el pasado, pero también tendencias al aumento en el último año o años. El índices refinado del Golfo de México indica una continua tendencia descendente en el período 1974-1981.

1. Introduction

The CPUE series from several fisheries and ichthyo-plankton survey have been used in the tuning process for the stock assessment of the western Atlantic bluefin at ICCAT SCRS. In this study, the age specific CPUE series for ages 3 to 5, 6 to 7 and 8 and older (8+) for the period of 1976 to 1992 were developed from the Japanese longline fishery operating in the western Atlantic north of 30°N during November to February. In addition, annual CPUE in the Gulf of Mexico, which covers adult stock abundance index (over 10 years old), was refined once again for 1974-1981 incorporating by-catch information. Those CPUE series were standardized by General Linear Model (GLM) procedure applying multiplicative model.

2. Material and Method

Two main areas were selected as shown in Fig. 1; Northwest (30°N-50°N, 45°W-80°W) and the Gulf of Mexico (20°N-30°N, 80°W-100°W). The Japanese longline catch and effort data used in this study cover the period from 1975 to 1992 and 1970 to 1981 for the Northwest and the Gulf of Mexico, respectively. The 1992 data were preliminary. Two sets of data were employed in the past studies (Miyabe 1991, 1992). One is categorized by month, 5-degree square and the kind of bait (referred to as "5 by 5 data"). The other, which is nearly the subset of the "5 by 5 data", includes additional information on the number of branch lines between floats that characterizes the gear configuration to some extent (referred to as "branch line data"). This data does not contain information of the kind of bait. In this study, only "branch line data" was used for the Northwest Atlantic since these data contain more information which is expected to affect CPUE significantly. The "branch line data" was updated this year incorporating the log book data submitted by the fishermen later on.

Nominal CPUEs in the Northwest Atlantic were aged by the slicing method on monthly basis applying the growth equation estimated by ICCAT (1991) to the available size data (fork length) measured on board of the Japanese longline boats. The matching between CPUE and size data was not always possible on the smallest strata (i. e., by month and 5-degree square). So the Northwest Atlantic was divided up to 9 areas, and two fishing seasons (Nov.-Dec. and Jan.-Feb.). These available size data were shown in Fig. 2 by 2 areas (east and west of 65°W) and fishing season. As was the case of previous analyses, CPUE indices were developed for 3 age groups; 3 to 5, 6 to 7 and 8+ age groups. Since it is known that the size of fish caught in the Gulf of Mexico were obviously over 200 cm in fork length, CPUE in this area is assumed to represent the abundance of adults stock.

GLM technique was applied to obtain annual trend of the CPUE. The multiplicative model was used as were the cases of previous works for this fishery (Cramer 1991; Davis and Turner 1989; Davis 1990; Miyabe and Suzuki 1989; Miyabe 1990, 1991, 1992). The model tested includes main effects of year, fishing season, area, gear (number of branch line between floats), CPUE of other species (albacore, bigeye, yellowfin, swordfish, white marlin and blue marlin) caught together and interaction term between these main effects except year and gear and between by-catch species. The model is shown below.

$$\mathrm{LOG}\ (\mathrm{CPUE}) = \mu + Y_{(i)} + M_{(j)} + A_{(k)} + G_{(l)} + \text{BY-CATCH}_{(m...)} + \mathrm{INT}_{(n...)} + e_{(ijkl...)}$$

where LOG : natural logarithm,
- CPUE : catch in number of bluefin per 10^6 hooks,
- μ : overall mean,
- $Y_{(i)}$: effect of year,
- $M_{(j)}$: effect of fishing season (month),
- $A_{(k)}$: effect of area,
- $G_{(l)}$: effect of gear (number of branch between floats) for "branch line data",
- $\text{BY-CATCH}_{(m...)}$: CPUE of other tunas and billfishes,
- $\mathrm{INT}_{(n...)}$: interaction term between above main effects except year and gear and between by-catch species,
- $e_{(ijk...)}$: error term with $N(0,\sigma)$.

The inclusion of these main effects and interaction was determined statistically on the basis of F-test.

As noted previously, the fishing season in the Northwest starts in fall and continues to spring. Therefore, it is assumed here that CPUE from a fishing season represents abundance index of the stock at the beginning of the latter calender year. That is, CPUE of 1989-1990 fishing season represents the abundance of 1990. Original area definition was shown in Fig. 1. Main effect of gear, which is the number of branch line (5-13) between floats, was incorporated into the model.

Number of observations was tabulated in Table 1 by main effect of year, month, and area. Zero catch observations were not used in this analysis. The number of zero catch observation and its percentage in the data base were shown in Table 2. The percentage of 0 catch observation on annual basis fluctuated greatly but more or less in the range of 10 - 30 % for the Northwest area. The same percentage for Gulf of Mexico exhibited decreasing trend.

Main area - Northwest

The number of observation does not show any specific trend by year and month (Table 1). However, since 1989 it has decreased in the nearshore areas (areas 10-11) and increased in the offshore areas (areas 4-6 and 20). The number of branch line between floats also shifted clearly from 5 during 1975-1979 to 7 since 1985 (Fig. 3). Observations were fewer in areas 1-8, 13-15 and 20-24 (Fig. 1). Taking these into consideration, area definition was modified slightly as shown in Fig. 4. Main effect and its number of levels included in the preliminary runs are as follows.

Year : 1976 - 1992, (17 levels)
Month : Nov. - Feb., (4 levels)
Area : 1 - 9, (9 levels)
Gear : 5 - 13, (9 levels)
By-catch CPUE: other tunas and billfishes (7 levels)

Gear effect was statistically significant except 3-5 age group (F > 2.0).

Main area - Gulf of Mexico

According to the reasons shown in the last year's analysis (Miyabe 1992), following levels of main effect were set in addition to the effect of by-catch.

Year : 1974 - 1981, (8 levels)
Month : February - June, (5 levels)
Area : 1 - 6, (6 levels)
By-catch CPUE : other tunas and billfishes (7 levels)

3.Result and Discussion

After several preliminary runs, final model was determined. The final model and the results of ANOVA are listed in Table 3. In the last year's analysis, "gear" effect was not statistically significant in all age groups in Northwest. This year's analysis shows, however, "gear" is significant both in 6-7 and 8+ age groups. It seems this is largely due to the renewal of data base. Regarding by-catch species, the largest component is bigeye, and all three tuna species stayed statistically significant in the model for Northwest. Interactions between by-catch species and month or area are less significant and tended to be out from the model. Mostly there was weak negative correlation between bluefin and by-catch species. Only swordfish was found to be positively correlated with bluefin 8+ age group. Among the by-catch species in the Gulf of Mexico, yellowfin was the most significant as expected.

R-square ranged from 0.53 to 0.62 for the Northwest, higher than the previous analysis possibly reflecting the increase of parameters by the introduction of by-catch to the model. On the other hand, R-square of the Gulf of Mexico jumped from 0.58 to 0.81 this year reflecting change in target species.

The distribution of overall residual from the final model (Fig. 5) is almost close to normal curve and can be acceptable. The distribution of normalized residual plotted at main effect year are shown in Fig. 6. Although in some cases the distribution is different from normal, it seems there are no systematic errors.

In Table 4, parameter estimate, least square mean of main effect year and their standard error were given. The estimated relative CPUEs (scaled to the earliest year) were shown in Fig. 7 and Table 4. CPUE of 3-5 age group was fairly high in 1977 and 1978 indicating the strong year class was passing through. After 1978 it has been stable with fluctuations (high in 1980 and 1985). Recent CPUE has been low but high in 1992. CPUE of 6-7 age group was high during 1977-1981. After the low level during 1982-1984, it recorded the highest in 1988. Then it declined once again but increased during the most recent two years. CPUE of 8+ age group indicated large fluctuation without any time trend. CPUE was higher in 1980-1981, 1984 and 1987. After the low level in 1989 it showed increasing trend. CPUE in the Gulf of Mexico indicated a constant downward trend during the period analyzed. 95 % confidence limits in 1974 were wide reflecting fewer observations of positive catch.

This trend for the Gulf of Mexico is the largest change from the previous analyses, and this is also attributable to the introduction of by-catch effect to the model.

The trend of CPUE for 3 - 5 and 6 - 7 age groups in the Northwest was consistent with previous analyses (Miyabe 1991, 1992; Suzuki 1986).

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Table 1. Number of observations for CPUE analysis by year, month and area.

Northwest

Year	Nov	Dec	Jan	Feb	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	Total
76	7	9	8	7	2	0	0	0	0	0	0	0	7	5	0	0	0	0	2	5	3	1	3	3	0	0	0	0	31
77	14	17	13	7	1	0	0	0	0	0	0	1	6	8	7	0	0	0	1	6	7	5	5	4	0	0	0	0	51
78	12	6	12	5	0	1	0	0	0	0	0	0	6	8	5	0	0	0	0	3	5	3	3	1	0	0	0	0	35
79	17	16	18	5	0	0	0	0	0	0	0	3	8	10	5	0	2	1	1	5	7	4	6	4	0	0	0	0	56
80	27	18	17	11	0	2	0	0	0	0	0	1	6	12	8	3	0	1	0	7	9	10	11	2	0	0	0	1	73
81	31	50	26	20	0	0	0	0	0	0	1	2	16	12	9	6	4	3	0	14	17	17	13	11	0	0	0	2	127
82	48	30	16	15	0	0	0	0	0	0	0	3	7	12	11	5	1	1	0	8	7	14	25	12	0	1	0	2	109
83	23	28	14	21	0	0	0	0	0	0	0	0	5	12	8	2	1	0	0	7	19	10	14	6	0	0	0	2	86
84	18	18	17	15	0	0	0	0	0	0	1	0	4	13	5	1	0	1	0	6	14	9	7	6	0	0	0	1	68
85	15	18	23	17	0	0	0	0	0	0	0	0	6	9	6	1	0	0	0	9	14	8	16	4	0	0	0	0	73
86	23	21	20	14	0	0	0	0	0	3	1	0	2	6	7	2	3	1	0	5	13	9	14	10	0	0	0	2	78
87	25	23	17	9	0	2	1	0	2	2	1	0	2	10	9	0	0	1	0	8	8	8	12	5	0	0	1	2	74
88	19	16	13	14	0	0	0	0	0	2	0	0	3	9	6	3	2	0	0	7	9	7	10	2	0	0	0	2	62
89	25	23	30	8	0	0	0	7	8	5	0	0	1	10	10	1	0	0	0	3	10	13	11	5	0	0	0	2	86
90	24	17	24	8	0	0	1	2	6	7	0	0	0	3	5	3	2	0	0	4	10	10	11	7	0	0	0	2	73
91	19	18	28	7	0	0	0	3	5	5	1	0	0	2	4	4	1	0	0	5	10	8	12	8	0	0	1	3	72
92	15	20	18	0	0	0	0	0	2	4	1	0	0	1	1	0	2	0	0	3	6	7	12	10	0	0	0	4	53
TOTAL	362	348	314	183	3	5	2	12	23	28	6	10	79	142	106	31	18	9	4	105	168	143	185	100	0	1	2	25	1207

Gulf of Mexico

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	A1	A2	A3	A4	A5	A6	A7	A8	Total
70	0	0	0	0	4	10	10	9	0	0	0	0	5	6	4	0	9	9	0	0	33
71	0	0	0	0	2	8	10	11	7	3	1	0	6	7	9	0	7	8	0	5	42
72	3	0	0	0	2	6	13	7	0	0	0	0	0	9	11	0	5	5	1	0	31
73	0	0	0	0	3	3	8	7	3	0	0	0	2	6	3	0	4	8	1	0	24
74	0	0	0	3	3	4	4	4	2	0	0	0	3	6	3	1	3	4	0	0	20
75	0	1	3	9	9	11	11	2	2	0	0	0	6	10	9	2	8	12	1	0	48
76	1	2	8	7	10	10	6	2	0	0	0	0	6	14	12	2	4	5	3	0	46
77	0	6	7	11	8	5	2	2	2	0	0	0	2	17	19	3	0	1	1	0	43
78	1	6	4	6	5	5	3	0	0	0	0	0	2	14	13	0	0	1	1	0	30
79	1	5	6	5	0	0	0	0	0	0	0	0	0	9	8	0	0	0	0	0	17
80	3	8	7	3	0	0	0	0	0	0	0	0	0	5	5	4	0	0	1	6	21
81	6	9	6	7	1	0	0	0	0	0	0	0	0	7	8	8	0	0	1	5	29
Total	15	37	41	51	47	62	67	44	16	3	1	0	32	110	104	20	40	53	9	16	384

Table 2. Number of "0 catch" and "positive catch" observation in the CPUE series used for GLM analysis.

3 - 5 age group

	0 catch		Positive		Total
Year	N	%	N	%	N
76	17	54.8	14	45.2	31
77	4	7.8	47	92.2	51
78	7	20.0	28	80.0	35
79	16	28.6	40	71.4	56
80	13	17.8	60	82.2	73
81	18	14.2	109	85.8	127
82	31	28.4	78	71.6	109
83	31	36.0	55	64.0	86
84	14	20.6	54	79.4	68
85	10	13.7	63	86.3	73
86	56	71.8	22	28.2	78
87	25	33.8	49	66.2	74
88	17	27.4	45	72.6	62
89	18	20.9	68	79.1	86
90	30	41.1	43	58.9	73
91	22	30.6	50	69.4	72
92	8	15.1	45	84.9	53
Total	337	27.9	870	72.1	1207

6 - 7 age group

	0 catch		Positive		Total
Year	N	%	N	%	N
76	19	61.3	12	38.7	31
77	4	7.8	47	92.2	51
78	4	11.4	31	88.6	35
79	14	25.0	42	75.0	56
80	21	28.8	52	71.2	73
81	39	30.7	88	69.3	127
82	31	28.4	78	71.6	109
83	31	36.0	55	64.0	86
84	8	11.8	60	88.2	68
85	11	15.1	62	84.9	73
86	56	71.8	22	28.2	78
87	19	25.7	55	74.3	74
88	17	27.4	45	72.6	62
89	18	20.9	68	79.1	86
90	25	34.2	48	65.8	73
91	18	25.0	54	75.0	72
92	8	15.1	45	84.9	53
Total	343	28.4	864	71.6	1207

8 + age group

	0 catch		Positive		Total
Year	N	%	N	%	N
76	17	54.8	14	45.2	31
77	21	41.2	30	58.8	51
78	6	17.1	29	82.9	35
79	14	25.0	42	75.0	56
80	13	17.8	60	82.2	73
81	51	40.2	76	59.8	127
82	31	28.4	78	71.6	109
83	31	36.0	55	64.0	86
84	8	11.8	60	88.2	68
85	11	15.1	62	84.9	73
86	56	71.8	22	28.2	78
87	19	25.7	55	74.3	74
88	20	32.3	42	67.7	62
89	18	20.9	68	79.1	86
90	25	34.2	48	65.8	73
91	18	25.0	54	75.0	72
92	8	15.1	45	84.9	53
Total	367	30.4	840	69.6	1207

Gulf of Mexico

	0 catch		Positive		Total
Year	N	%	N	%	N
72	24	77.4	7	22.6	31
73	19	79.2	5	20.8	24
74	15	75.0	5	25.0	20
75	23	47.9	25	52.1	48
76	11	23.9	35	76.1	46
77	9	20.9	34	79.1	43
78	5	16.7	25	83.3	30
79	0	0.0	17	100.0	17
80	4	19.0	17	81.0	21
81	4	13.8	25	86.2	29
Total	114	36.9	195	63.1	309

Table 3. Results of ANOVA from the General Linear Model for the western Atlantic bluefin.

Northwest

Age group	Source of variation	Sum of square	Degree of freedom	Mean Square	F statistics	R^2
3-5	Y + M + A + ALB + BET + YFT + WHM + M*A + ALB*A + YFT*A					
	Model	2006.2460	71	28.2570	17.10	0.62
	Error	1208.0730	731	1.6526		
	Total	3214.3191	802			
6-7	Y + M + A + B + ALB + BET + YFT + M*A + BET*MONTH + BUM*MONTH					
	Model	1321.2348	69	19.1483	13.01	0.55
	Error	1077.4073	732	1.4719		
	Total	2398.6421	801			
8+	Y + M + A + B + ALB + BET + YFT + SWO + BUM + M*A + ALB*M + YFT*A + SWO*A + BUM*M					
	Model	1177.4781	65	18.1151	12.16	0.53
	Error	1057.9040	710	1.4900		
	Total	2235.3822	775			

Gulf of Mexico

Source of variation	Sum of square	Degree of freedom	Mean Square	F statistics	R^2
Y + M + A + BET + YFT + BUM + BET*M + YFT*M + YFT*A + BUM*AREA					
Model	193.8328	37	5.2387	15.25	0.81
Error	46.7102	136	0.3435		
Total	240.5430	173			

Table 4. Parameter estimates and Least Square Means for main effect of year in the GLM analysis, and estimated relative annual CPUE scaled to the earliest year.

3 - 5 age group

	Parameter		Least Square Mean		Relative
Year	Estimate	Std Err	Estimate	Std Err	CPUE
76	1.0776	0.4990	6.8019	0.4158	1.0000
77	1.1891	0.3711	6.9134	0.2592	1.1180
78	0.9575	0.3903	6.6818	0.2871	0.8868
79	-0.7640	0.3438	4.9601	0.2245	0.1585
80	0.5052	0.3466	6.2295	0.2207	0.5642
81	0.1504	0.2928	5.8747	0.1526	0.3957
82	-0.2431	0.3050	5.4811	0.1750	0.2669
83	-1.0876	0.3205	4.6366	0.2080	0.1147
84	-0.1517	0.3197	5.5724	0.2038	0.2924
85	-0.1460	0.3272	5.5781	0.1998	0.2941
86	-0.4437	0.3876	5.2805	0.2993	0.2184
87	-0.9401	0.3188	4.7841	0.2089	0.1329
88	-0.6090	0.3152	5.1152	0.2155	0.1851
89	-0.7939	0.3067	4.9303	0.1920	0.1539
90	-0.6709	0.3123	5.0533	0.2273	0.1740
91	-1.1486	0.3173	4.5756	0.2170	0.1079
92	0.0000		5.7242	0.2572	0.3404

Table 4. Continued.

6 - 7 ages group

	Parameter		Least Square Mean		Relative
Year	Estimate	Std Err	Estimate	Std Err	CPUE
76	-1.3741	0.4808	4.2872	0.4416	1.0000
77	-0.2593	0.3436	5.4021	0.2665	3.0493
78	-0.0728	0.3602	5.5886	0.2886	3.6744
79	-0.1505	0.3108	5.5108	0.2310	3.3994
80	-0.5087	0.3114	5.1526	0.2312	2.3760
81	-0.3084	0.2650	5.3530	0.1753	2.9032
82	-1.0133	0.2703	4.6480	0.1723	1.4345
83	-1.1552	0.2833	4.5061	0.2082	1.2447
84	-0.9496	0.2835	4.7117	0.1923	1.5288
85	-0.4419	0.2885	5.2194	0.1994	2.5401
86	-0.5572	0.3479	5.1041	0.2900	2.2635
87	-0.3794	0.2698	5.2819	0.2067	2.7039
88	0.0383	0.2783	5.6998	0.2183	4.1066
89	-0.6573	0.2624	5.0041	0.1883	2.0481
90	-1.0434	0.2723	4.6179	0.2136	1.3919
91	-0.4537	0.2716	5.2076	0.2128	2.5103
92	0.0000		5.6614	0.2411	3.9519

8 + ages group

	Parameter		Least Square Mean		Relative
Year	Estimate	Std Err	Estimate	Std Err	CPUE
76	-1.6749	0.5008	3.2188	0.4299	1.0000
77	-0.8351	0.4261	4.0586	0.3438	2.3159
78	-0.6475	0.4144	4.2462	0.3209	2.7938
79	-0.9037	0.3412	3.9900	0.2428	2.1624
80	-0.0386	0.3393	4.8551	0.2384	5.1361
81	0.3197	0.2936	5.2135	0.1912	7.3500
82	-0.6598	0.2984	4.2340	0.1819	2.7599
83	-0.9842	0.3088	3.9095	0.2173	1.9951
84	0.1223	0.3029	5.0161	0.1992	6.0333
85	-0.3147	0.3128	4.5790	0.2076	3.8970
86	-0.0289	0.3640	4.8649	0.2860	5.1867
87	0.3983	0.2912	5.2921	0.2123	7.9510
88	-0.4079	0.2967	4.4858	0.2273	3.5502
89	-0.6324	0.2872	4.2613	0.1956	2.8363
90	-0.4505	0.2836	4.4432	0.2222	3.4021
91	-0.1213	0.2888	4.7724	0.2177	4.7285
92	0.0000		4.8938	0.2606	5.3388

Gulf of Mexico

	Parameter		Least Square Mean		Relative
Year	Estimate	Std Err	Estimate	Std Err	CPUE
74	1.5696	0.4379	7.5327	0.4367	1.0000
75	0.8417	0.2422	6.8048	0.2516	0.4829
76	0.9611	0.2131	6.9242	0.2571	0.5442
77	0.2727	0.1885	6.2358	0.2627	0.2734
78	0.4564	0.2019	6.4195	0.2824	0.3285
79	0.6583	0.2107	6.6214	0.2881	0.4020
80	0.0407	0.2296	6.0038	0.3082	0.2168
81		0.0000	5.9630	0.2761	0.2081

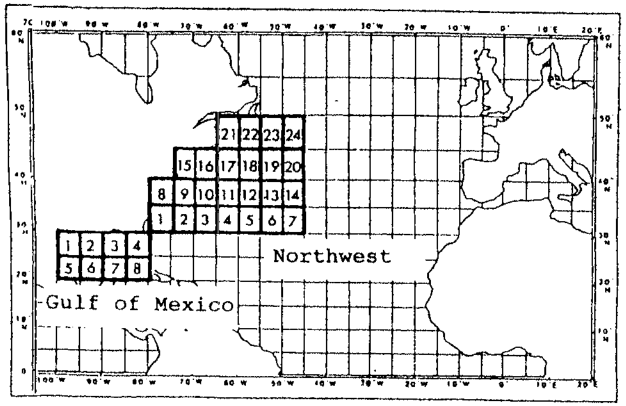

Figure 1. Area division for main areas "Northwest" and "Gulf of Mexico".

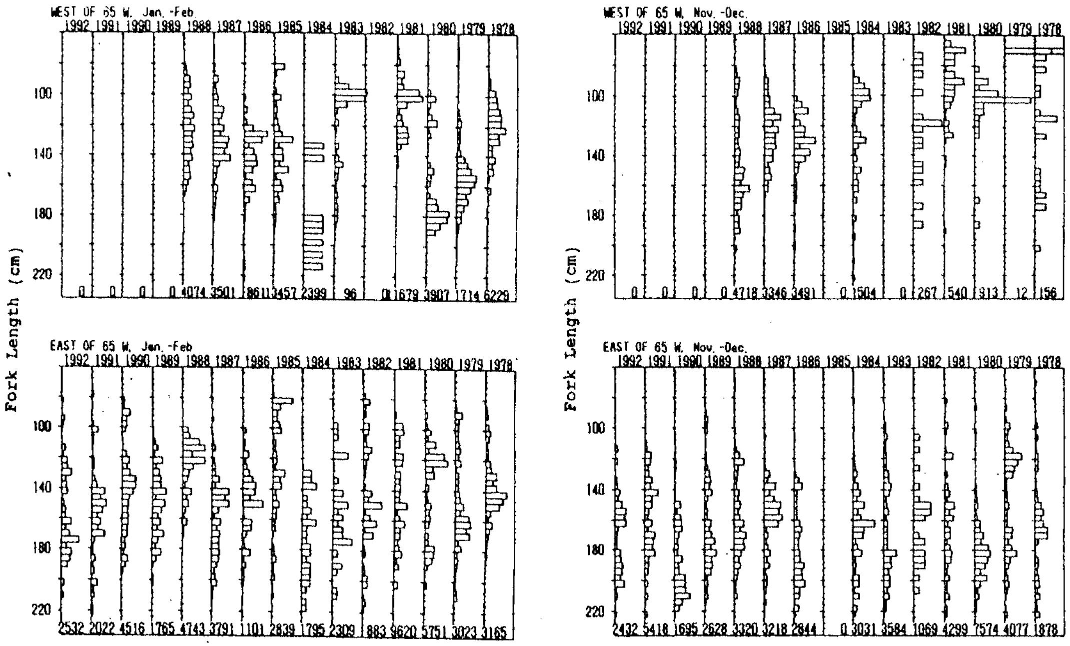

Figure 2. Available length frequency of bluefin tuna in the main area "Northwest" by two areas (east and west of 65°W) and two bimonthly period (November-December and January-February) for the calender years 1976-1992.

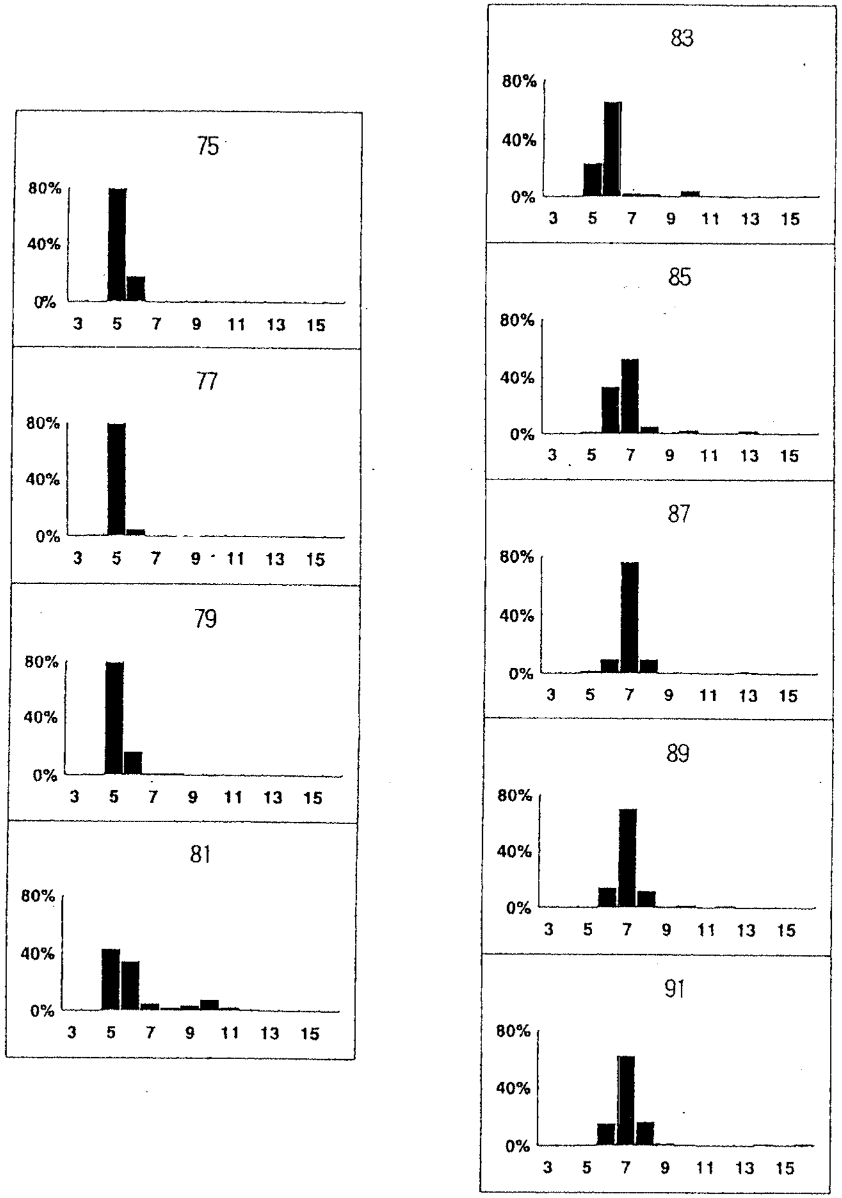

Figure 3. Relative frequency of the fishing effort (hooks) by the number of branch lines (3-16) between floats in the Northwest.

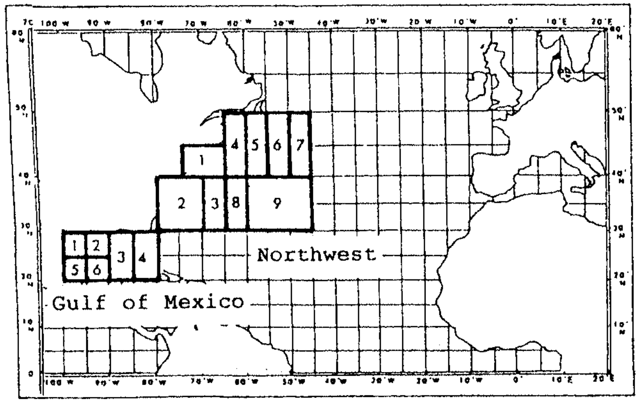

Figure 4. Area division used in the final model.

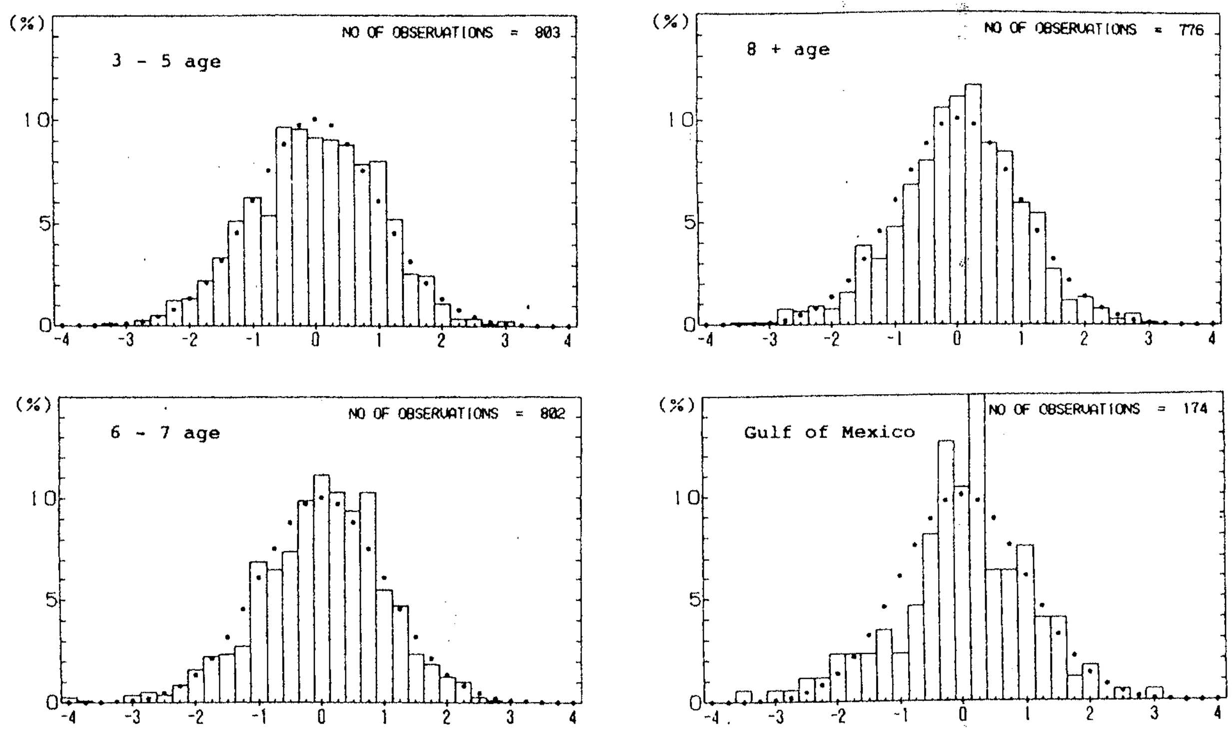

Figure 5. The histograms of total standardized residual. Bars show freqency of residual and solid circle show normal distribution.

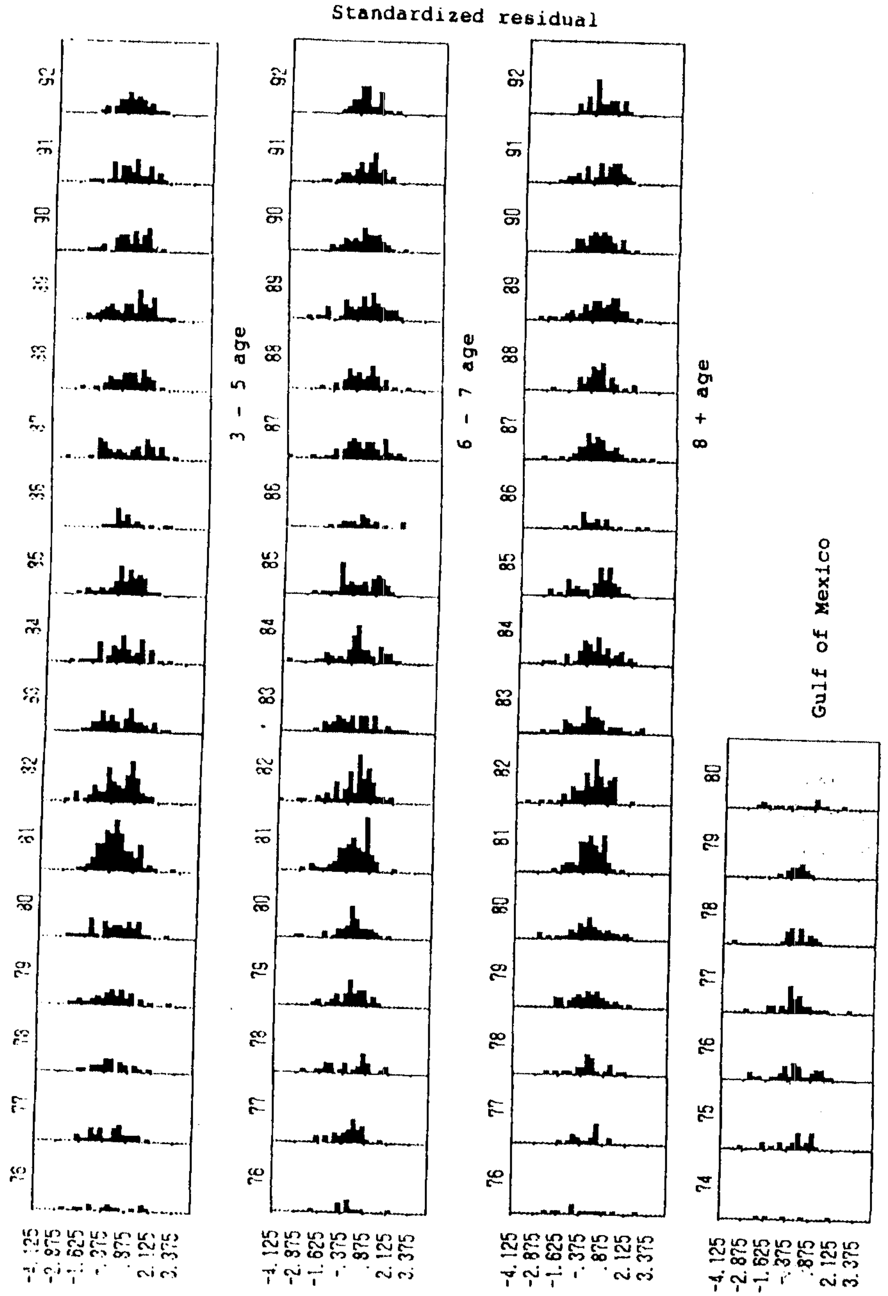

Figure 6. The histograms of standardized residual plotted at main effect year.

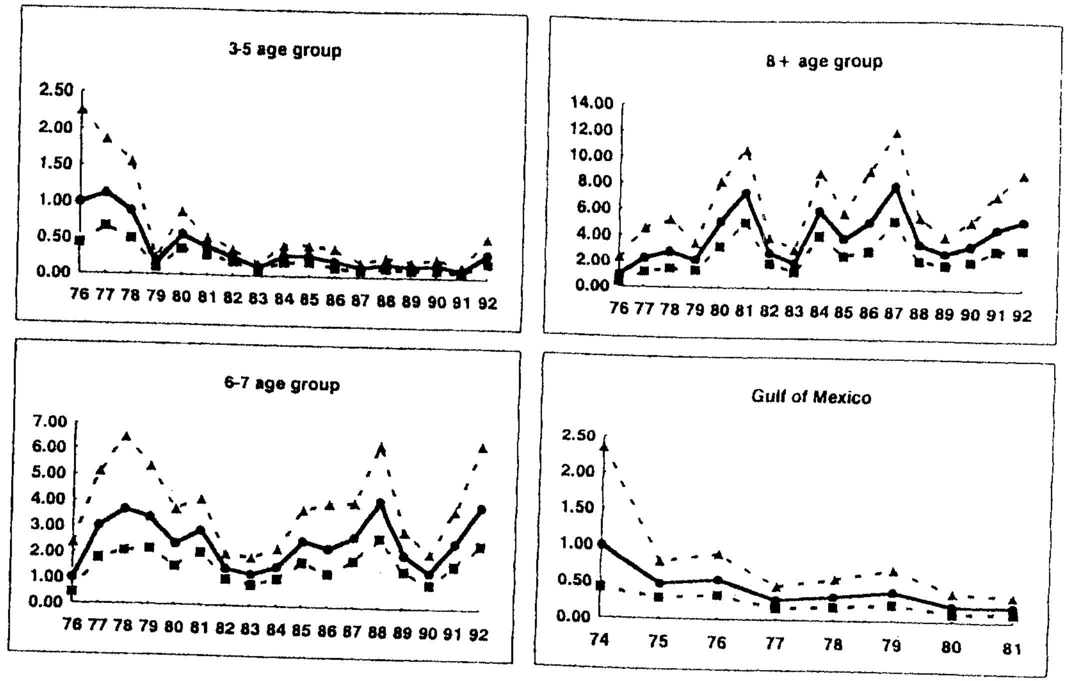

Figure 7. Estimated annual relative CPUE scaled to the earliest year. Solid and broken lines indicate estimated CPUE and its 95% confidence limits, respectively.